Space Weather Technical Forecast

Issued on Tuesday 7 January 2025 at 01:29 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Further M-class flares likely. Chance of Active electron fluence 08 and 09 Jan. Slight chance G1 Minor geomagnetic storm conditions 07 Jan.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with three M-class flares observed, all originating from AR3947 in the northeast of the visible disc. The peak flare was a M4.8 level event at 06/1624 UTC.

There are currently ten sunspot regions on the visible disc. Despite the number of spots on the Earth facing-disc, many are small and generally magnetically simple with limited change in appearance in the past 24-hours. AR3947 (Eac/Beta-Gamma) in the northeast is the largest and most magnetically complex region, however, it has simplified in the period with decay of its interior delta configuration and spreading of its main lead and trailing spots. Some slight emergence of small, intermediate spots was in evidence in recent hours, however.

An M4.8 flare, peaking 06/1624 UTC and associated coronal dimming from AR3947 may have resulted in a CME, however, available coronagraph imagery is limited at this time to be able to corroborate this. Further analysis will take place to determine if there has been an Earth-directed CME from this event, but current indications are that this has not occurred.

Solar Wind / Geomagnetic Activity: The solar wind environment was enhanced due to the ongoing, but slowly declining connection to a large coronal hole (CH05/+) in the northwest disc. Solar wind speeds observed by ACE at L1 were Elevated to Strong, broadly declining from around 550km/s to 500km/s during the period, but with a peak of 616km/s at 06/1532 UTC. Density was below average throughout. The Interplanetary Magnetic Field, Bt, was weak, peaking at 7nT. The north-south component, Bz, varied weakly, ranging between +5/-5nT with no single orientation dominant. The Phi angle was mostly positive (away from the Sun).

Geomagnetic activity was Quiet to Active (Kp2-4).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) at GOES-18 was below the S1/Minor Storm threshold, but slightly above normal background levels (on a declining trend).

High energy electron flux (greater than 2MeV) at GOES16 was at Moderate to diurnally High levels with the associated 24 hr fluence staying below the Active threshold, but on a rising trend. The

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07/0000 UTC fluence observation was 5.79e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High, with further M-class flares likely and a slight chance of isolated X-flares, mainly from AR3947.

Solar Wind / Geomagnetic Activity: There is a slight chance of a glancing blow from a CME early on Day 1 (07 Jan), but it is more likely that the CME will pass ahead of Earth's orbit. Similarly, a CME that left the Sun on 03 Jan is also expected to miss Earth. Further analysis is required for a potential CME that occurred on 06 Jan, with updates to be provided in subsequent bulletins.

Earth's connection to a high-speed stream associated with a large coronal hole is forecast to wane over the next few days. Elevated solar winds are expected to decline to Slightly Elevated levels on Day 1 (07 Jan), perhaps returning to background levels by Day 2 (08 Jan). The next coronal hole enhancement is likely on Day 4 (10 Jan), but forecast to be weaker with speeds probably peaking at Slightly Elevated levels.

Geomagnetic activity is expected to be Quiet to Active on Days 1 and 4 (07 and 10 Jan) and Quiet to Unsettled on Days 2 and 3 (08 and 09 Jan). There is a slight chance of peak G1/Minor Storm conditions on Day 1 (07 Jan) should any CME influence occur.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is below the S1/Minor Storm threshold, but slightly above normal background levels (on a declining trend). There is a slight chance of exceeding the S1/Minor Storm threshold during the period.

GOES16 high energy electron flux is currently varying between Moderate and diurnally High levels following the connection to a strong high-speed stream from a coronal hole. Electron flux is likely to see further peaks of High levels in the coming several days before declining late in the period. The associated fluence is likely to remain below the Active threshold. However, due to the heightened potential for rising electron flux levels, there is a chance that fluence could exceed the Active threshold, mainly on Days 2 and 3 (08 and 09 Jan).

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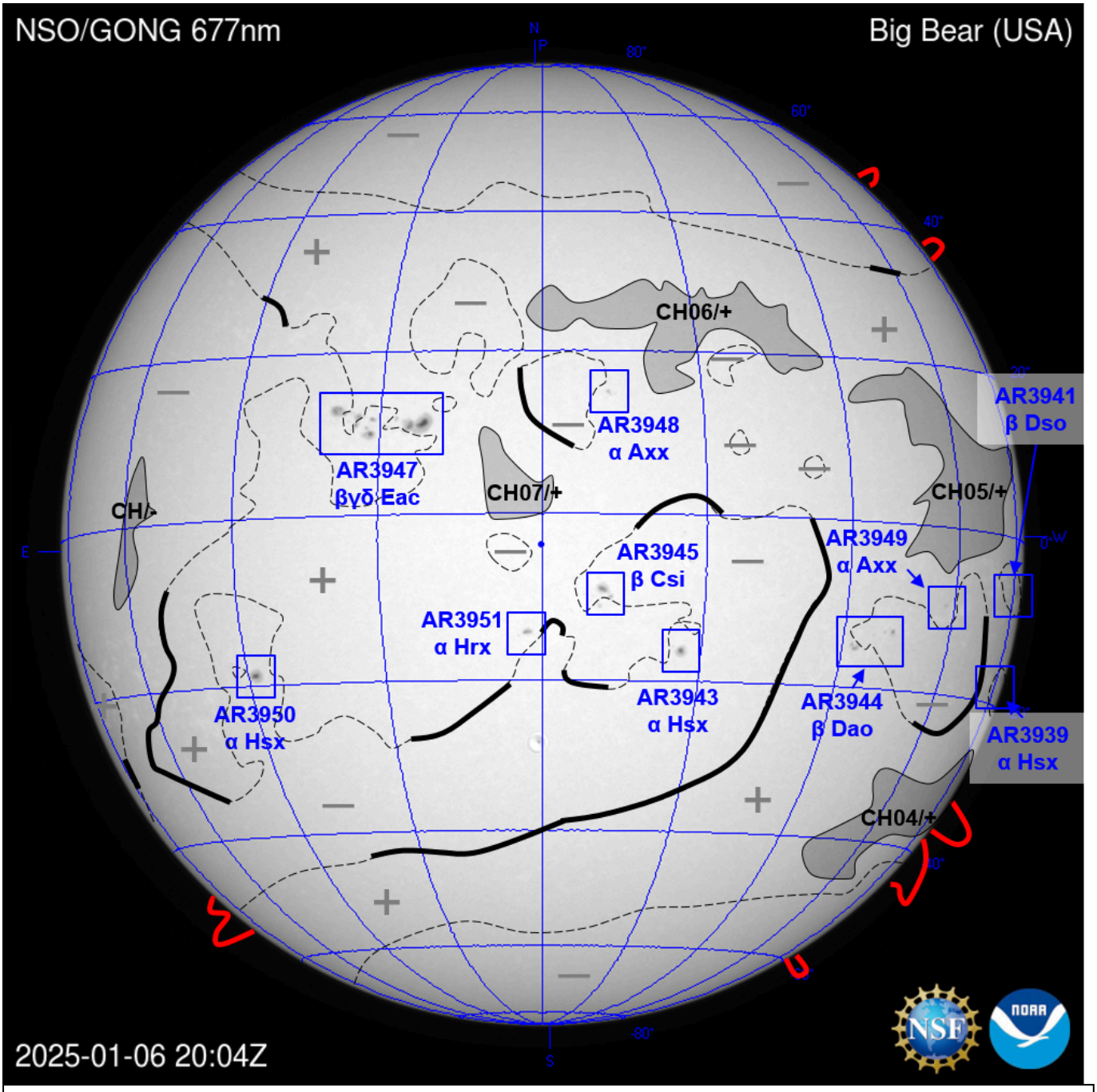
Figure 1: MOSWOC Solar Synoptic Map valid 06/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

Two CMEs occurred from AR3939 in association with C-flares at 04/1444 and 04/1827 UTC. It is likely both of these CMEs will pass ahead of Earth's orbit, however there is a slight chance that the latter CME may deliver a glancing blow late 06 Jan, or early on Day 1 (07 Jan). A slow CME from the X1.1 flare of AR3947 on 03 Jan is expected to pass behind Earth orbit on Day 3 (09 Jan). An M4.8 flare, peaking 06/1624 UTC and associated coronal dimming from AR3947 may have resulted in a CME, however, available coronagraph imagery is limited at this time to be able to corroborate this. Further analysis will take place to determine if there has been an Earth-directed CME from this event.

Earth has been connected to a high-speed stream associated with CH05/+ in the northwest of the solar disc since 04/1400UTC. This coronal hole was originally a larger hole consisting of CH05/+ and CH06/+ which has since been split into two. Both coronal holes are persistent, although were smaller and further to the solar east on last rotation. Solar winds have been declining slowly over the past 24 hours and are expected to continue this decline over the coming days. Initially Elevated solar winds should decline to Slightly Elevated levels on Day 1 (07 Jan), perhaps returning to background levels by Days 2 and 3 (07-08 Jan). The next coronal hole enhancement expected is from CH07/+ on Day 4 (10 Dec), currently located near centre disc in the Sun's northern disc. This feature is also recurrent from the last rotation in December and gave speeds of near 450km/s. By comparison, the coronal hole now appears smaller, and potentially slightly weaker than last month, so tentatively speeds of around 400km/s (Slightly Elevated) are possible following the onset of the high-speed stream.

MOSWOC ENLIL was too late in bringing the onset of the ongoing high-speed stream and will consequently be slightly delayed in its decline, but the indicated reduction in wind speeds in the coming days is accepted, as is the minor increase on Day 4 (10 Jan) likely associated with CH07/+.

Geomagnetic activity is expected to be Quiet to Active on Days 1 and 4 (07 and 10 Jan) and Quiet to Unsettled on Days 2 and 3 (08 and 09 Jan). There is a slight chance of peak G1/Minor Storm conditions on Day 1 (07 Jan) should any CME influence occur.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	1	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Figure 2: Latest Enlil model output valid 07/0300 UTC indicating 'near-miss' of CME ahead of Earth orbit from 04 Jan event.

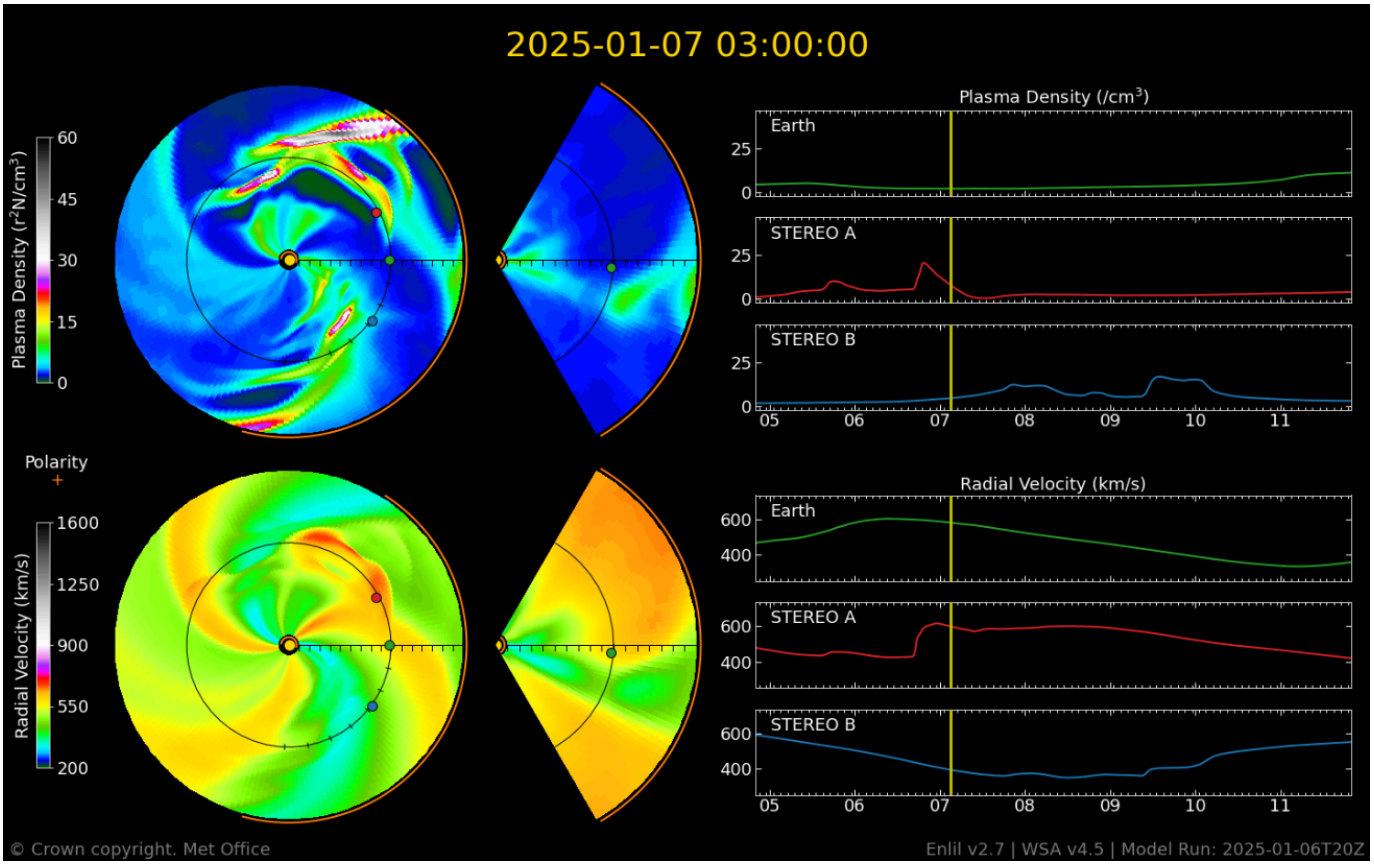
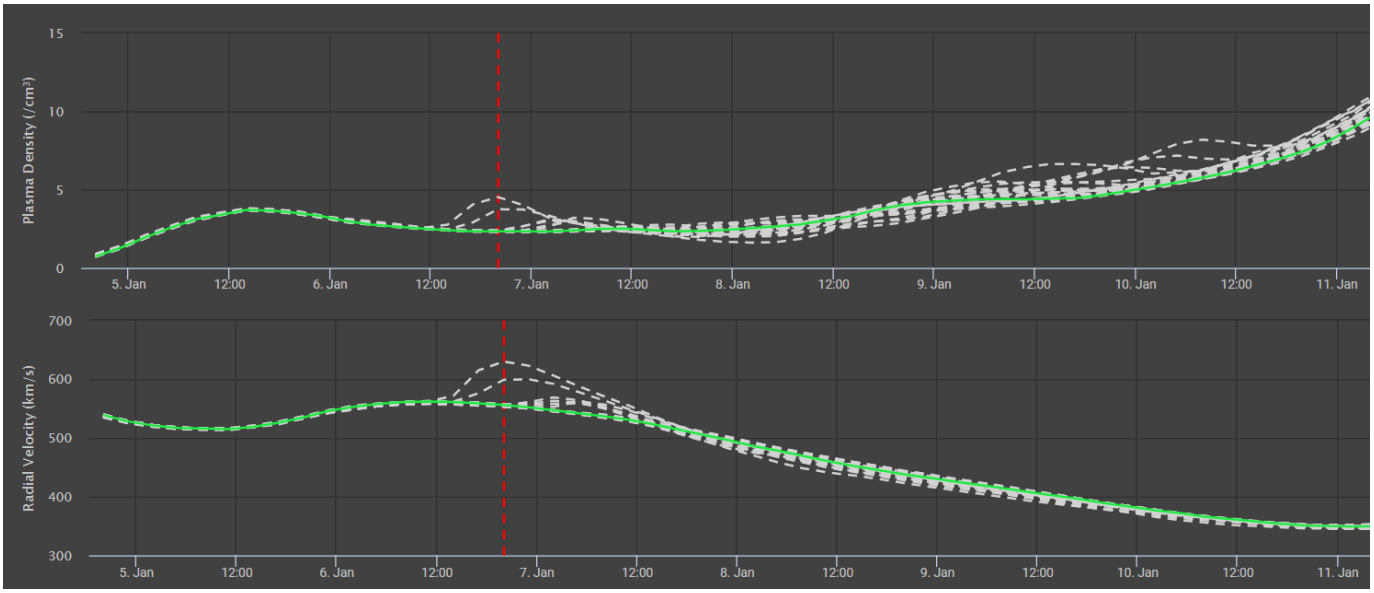


Figure 3: Latest Enlil model Ensemble output.



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Radio Blackouts - X-Ray Flares

Solar activity has been Moderate with three M-class flares observed, all originating from AR3947 in the northeast of the visible disc. The peak flare was an M4.8 level event at 06/1624 UTC.

There are currently ten sunspot regions on the visible disc. Despite the large number of spots on the Earth facing-disc, the majority are small and generally magnetically simple. AR3947 remains the largest and most magnetically complex region, responsible for the majority of recent activity. This region features several moderately sized spots, including some minor growth of the main trailing region and emergence of some intermediate spots. However, the previous delta configuration has now decayed, meaning that the region has been reclassified as a Beta-Gamma group according to the Mount Wilson classification system of sunspots. The next largest spots, AR3944 and AR3945, both in the southwest, are fairly small and simple bipolar groups with limited magnetic complexity.

GOES-16 SUVI 171 imagery shows notable looping on the southeast limb with far-sided data showing a returning region (Ex-AR3930) likely to emerge in the coming 24 hours with a previous history of M-class flares.

Given that AR3947 has been the most active region and will remain on the solar disc for the next four days, the flare risk is maintained at a steady level throughout this period, pending any further developments.

Overall, activity is forecast to be Moderate to High, with further M-class flares likely and a slight chance of isolated X-flares, mainly from AR3947.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	70	70	70	70
Very Active	R3-R5 (X Class)	No	10	10	10	10

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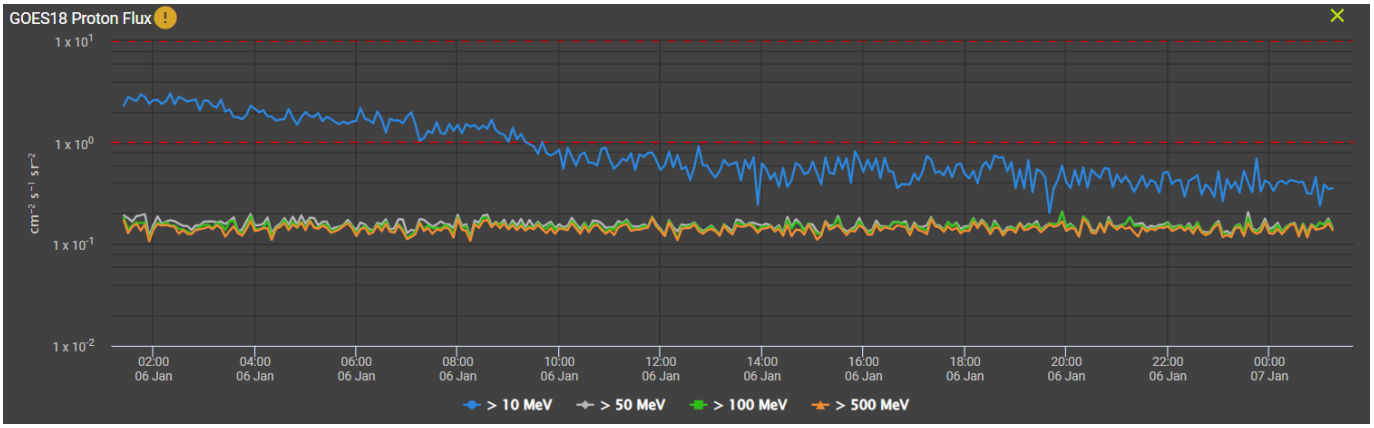
Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux is below the S1/Minor Storm threshold, but slightly above normal background levels (on a declining trend), following an enhancement from the C9.1 flare from AR3939 on 04 Jan. There is a slight chance of further enhancements during the forecast period should any further significant flares occur. This risk is maintained throughout, despite AR3939 rotating over the western limb on Day 1 (07 Jan) as active sunspot region AR3947 makes its way into the western hemisphere by the end of Day 2 (08 Jan) and into a more favourable location for proton enhancements to be detected at L1.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest GOES18 Proton Flux trace.



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High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 is currently varying between Moderate and diurnally High levels following the connection to the high-speed stream of CH05/+. This high-speed stream previously resulted in strong solar winds, which may have charged the radiation belts with electrons. As a result, it is likely that we see electron levels peak at occasionally High levels in the coming days, before subsiding late in the period. Significant geomagnetic activity is unlikely during the period, but is possible should we see any impact from a CME that left the Sun on 04 Jan. This would cause the cause the electron belts to become surprised away from GEO on Day 1 (07 Jan), although this is viewed with low confidence, before then expanding back out and causing the electron flux to rise again once any geomagnetic activity has ceased. The onset of a new high-speed stream on Day 4 (10 Jan) from CH07/+ is anticipated to lower electron counts at GEO to background or Moderate levels.

The associated 24-hour fluence is likely to remain below the Active threshold. However, due to the heightened potential for rising electron flux levels, there is a chance that fluence could exceed the Active threshold, mainly on Days 2 and 3 (08 and 09 Jan), as suggested by MOSWOC REFM.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	10	30	40	20
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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Figure 5: Latest GOES16 >2MeV Electron Flux (above) and MOSWOC REFM forecast and Recurrence (below).

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